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# Topology Optimization of Truss-Like Continuum under Uncertain Load

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## Abstract

To make the structural optimization more robust in real world, it is important to account for the uncertainty [1]. Here a topology optimization method of truss-like continuum [2] under uncertain load was presented. The load was uncertain and its probability distribution was unknown. The uncertain load was described by interval variables [3] $\boldsymbol{F} = \boldsymbol{F}^{\mathrm{c}} + \boldsymbol{F}^{\mathrm{r}}\delta$, where $\boldsymbol{F}^{\mathrm{r}}$ and $\boldsymbol{F}^{\mathrm{c}}$ was the width and midpoint of interval variable $\boldsymbol{F}$, $\delta$ was a standard interval variables $\delta \in [-1,1]$. Structure was analysed based on the interval theory. The stress along any orientation $\alpha$ was expressed as

$$\sigma(\alpha) = \boldsymbol{Q}(\alpha)(\boldsymbol{F}^{\mathrm{c}} + \delta\boldsymbol{F}^{\mathrm{r}})$$

where

$$\boldsymbol{Q}(\alpha) = [\cos^2\alpha \quad \sin^2\alpha \quad \sin 2\alpha]\boldsymbol{D}\boldsymbol{B}\boldsymbol{K}^{-1}$$

$\boldsymbol{D}$ was elastic matrix; $\boldsymbol{B}$ was geometric matrix; $\boldsymbol{K}$ was structural stiffness matrix. The maximum stress and its direction under the most unfavourable load case was calculated by

$$\left|\sigma(\alpha_{\mathrm{m}})\right| = \left|\boldsymbol{Q}(\alpha_{\mathrm{m}})\boldsymbol{F}^{\mathrm{c}}\right| + \left|\boldsymbol{Q}(\alpha_{\mathrm{m}})\right|\boldsymbol{F}^{\mathrm{r}}$$

The strain along the direction of maximum stress under the most unfavourable load was calculated as

$$\left|\varepsilon(\alpha_{\mathrm{m}})\right| = \left|\boldsymbol{P}(\alpha_{\mathrm{m}})\boldsymbol{F}^{\mathrm{c}}\right| + \left|\boldsymbol{P}(\alpha_{\mathrm{m}})\right|\boldsymbol{F}^{\mathrm{r}}$$

where

$$\boldsymbol{P}(\alpha) = [\cos^2\alpha \quad \sin^2\alpha \quad \sin 2\alpha/2]\boldsymbol{B}\boldsymbol{K}^{-1}$$

The truss-like continuum material model was used. The volume of the structure with the stress constraints was minimized. The density distribution field of member in truss-like continuum is optimized by fully-stressed criterion. The members were aligned along the angle $\alpha_{\mathrm{m}}$. The structures are optimized by the iterative procedure.

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## References

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